FEAGRI Faculdade de Engenharia Agrícola — UNICAMP

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MOIRÉ SUPPORTED STRAIN DISTRIBUTION DETERMINATION ON MACHINE ELEMENTS OF DISCONTINUOUS GEOMETRY

Prof. Ph.D. Eng. Jonathan Gazzola[(1)], Ph.D. Stud. Eng. Kellen C. Cardoso[(2)], Ph.D. Stud. Eng. Marcos V. G. Silva[(2)], Prof. Ph.D. Eng. Inácio M. D. Fabbro[(2)]

[(1)]Department of Agricultural Engineering, UFS, Aracaju, SE, Brazil

[(2)] Faculty of Agricultural Engineering, UNICAMP, Campinas, SP, Brazil.

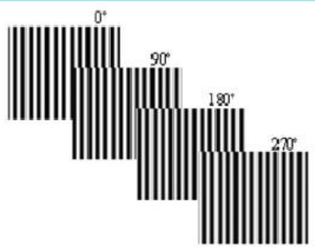
Tel: +55 19 3521-1059; E-mail: inacio@feagri.unicamp.br

Abstract

A diaphragm spring was chosen as a machine element of complex geometry, which integrates the clutch assembly. The tabs misalignment may result in vibrations transmitted to the clutch system, as well as difficulties in driving the pedal and can also generate components deformation and thus premature wearing of the whole clutch system. The displacement of the diaphragm spring during clutch driving promotes alterations on the stress and strain distribution on its profile as well as on the components associated to the spring, and tabs misalignment turns this distribution not uniform. The determination of stress and strain is widely used in engineering. Classical methods as electrical strain gage, mechanical gage and finite element simulations are useful to the qualification and quantification of load distribution in the specimens. Photoelastic techniques are gaining space, because it facilitates the stress and strain distribution determination, allowing clear visualization of the undergoing phenomena based on a quick and reliable experimentation. The shadow *moiré* and projection *moiré* techniques are the most commonly used methods primarily due to its measurement simplicity and quickness which supports frequent studies and proposed applications. The advantage of using *moiré* techniques is associated to the requirement of simple experimental setup for image acquisition and processing as well as its application to bodies of simple or complex geometry. The purpose of this study was to apply a *moiré* technique to obtain the stress and strain qualification and quantification on a spring membrane taken as a machine component of complex geometry. The shadow *moiré* technique can assist the simulation to determine the strain, stress distribution on diaphragm spring surface. The computer simulation by finite element technique and strain gauges, were used as the basis of comparison between the results obtained by the *moiré* method to validate the application of the proposed optical method to study of mechanical elements of complex geometry.

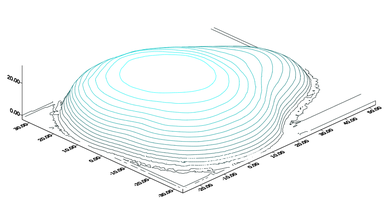
Introduction

PHASE-SHIFTING MOIRÉ

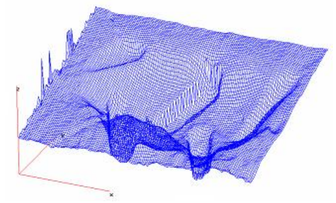


Digital Ronchi Grids

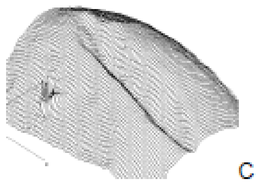
APPLICATION IN AGRICULTURAL ENGINEERING

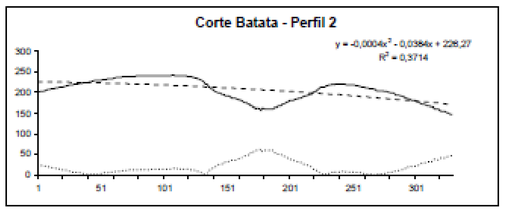


Digital Elevation of Pears
Source: Lino , 2008



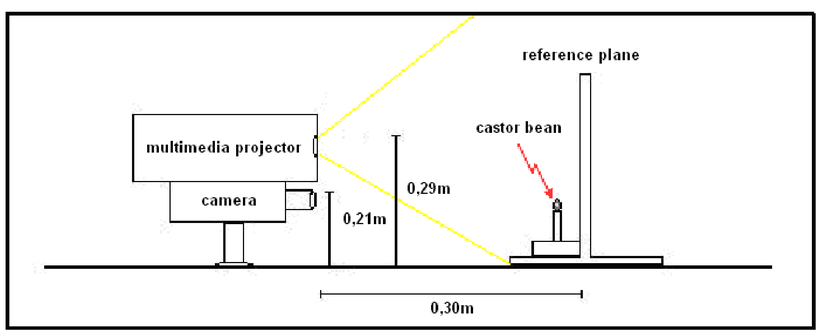
Digital Elevation of Compacted Soil
Source: Kuninari et al., 2008





Digital Elevation of Damages in Potatoes
Source: Lino , 2008

Methods & Materials



Experimental Setup to Phase-Shifting Moiré

ImageJ — Image Processing and Analysis in Java

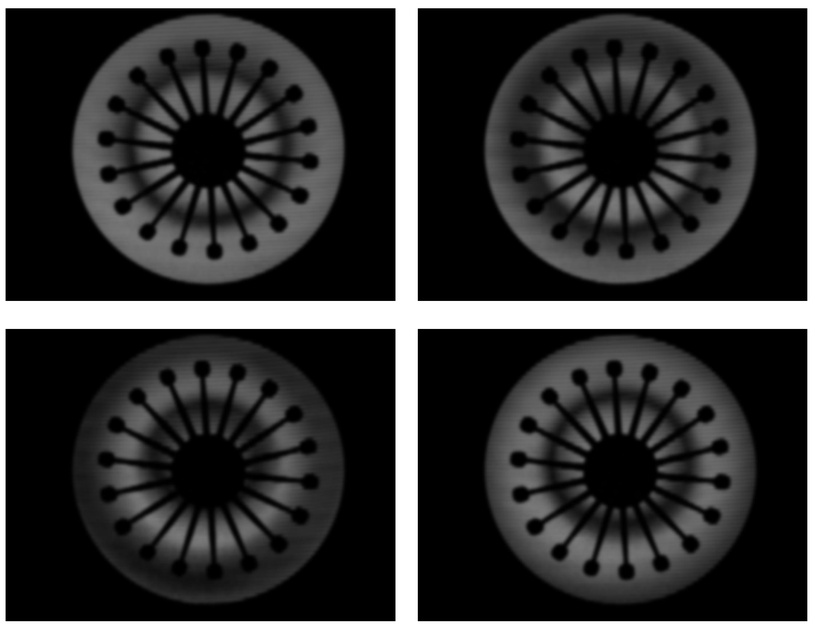
Isolated Image Processing
Color Elevation
Graphic Coordinates

Scilab

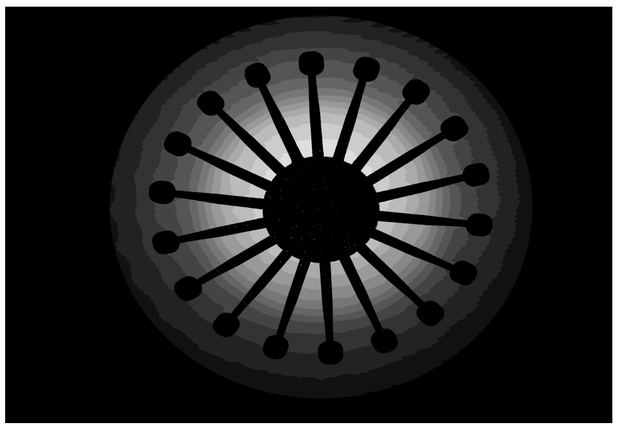
Image Calculation
Unwrapped Phase of Images

Results

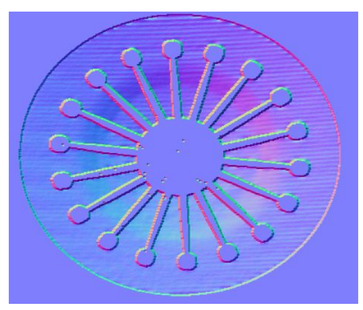
GRIDS INTERACTION



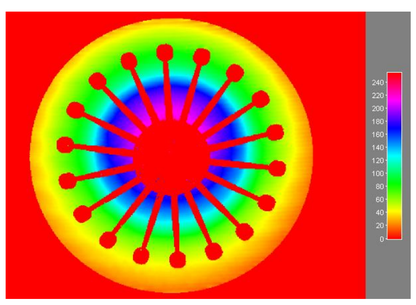
Unwrapped Image Resultant

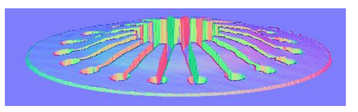


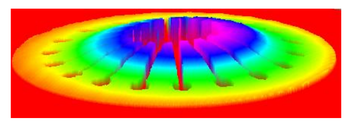
Gradient Topographic Map

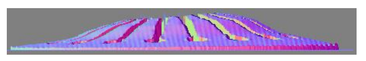


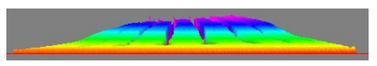
Color Topographic Map

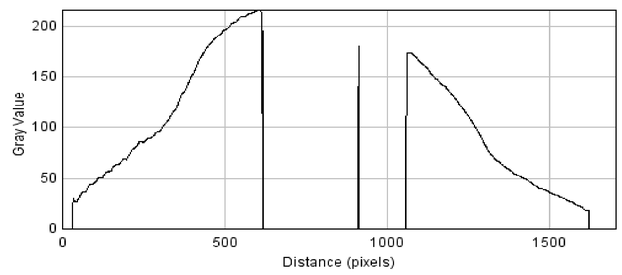


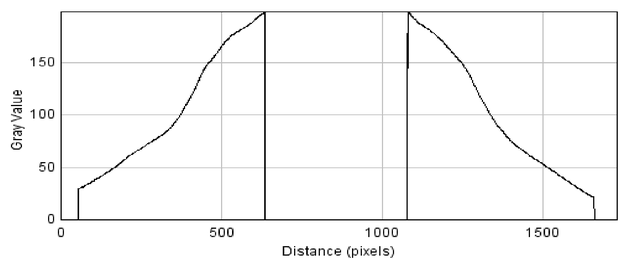












Discussion

✓ Results shows slight enclination between top and botton borders, which is caused by two error sources: (1) this first one is associated the body geometry, in which the elements are different from each other. (2) The second one related to grid projection and capture.
✓The relative angle between the camera and the multimedia projector generates a slight inclination of the testing element.
✓ These errors can be minimized by improving the setup adjustment.

Conclusions

Based on what it has been exposed before it can be concluded that the moiré technique is useful to carry topographic survey of bodies showing discontinuous geometry. The results as presented in color mapping as well as in pixels can be easily transformed into dimensional units which would be applicable to quality control as well as to reverse engineering. Projection errors minimization, comparative topographic survey including laser scanning, contact equipment and caliper are highly recommended.